



Space Station / Shuttle / Mars Electronics

Space Weather Forecast Requirements

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JSC Missions

EA44/Station Engineering Office

Pat O'Neill

02/09/00

- **Space Shuttle (150 - 350 nmi, to 57 deg)**
 - **Avionics Upgrades (flight computers, displays, mass storage, etc.)**
- **International Space Station (Low Earth Orbit 51.6 deg)**
 - **US, Canadian, Russian, Europeans, Japanese**
- **Mars /01, /03**
 - **Mars In-Situ Propellant Production (MIPS)**
 - **Mars Radiation Environment Experiment (MARIE)**
- **Government Furnished Equipment (GFE)**
 - **avionics common to Space Station & Shuttle**
 - **GPS Navigation, laptops, EVA, communications with ISS**



*Space Shuttle Electronics - Our
Space Weather Program*

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- **New General Purpose Flight Computers installed on STS-37 (April 1991)**
 - **SRAM memory susceptible to soft errors, EDAC corrects and time tags**
 - **Since STS-37: 56 STS missions, 570 days on-orbit, 7000 single event upsets**
 - **SEU's correlate with geomagnetic cutoff and South Atlantic Anomaly**
 - **No major solar flares, no direct correlation with space weather
A major solar flare could cause excessive SEU's**



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**ACTUAL SEU'S - QUIET SUN &
GEOMAGNETIC FIELD**

**SIMULATED - MAJOR SOLAR
FLARE, NO GEOMAGNETIC FIELD**



<i>ISS Electronics - Our Space Weather Program</i>	<i>EA44/Station Engineering Office</i>	
	<i>Pat O'Neill</i>	<i>02/09/00</i>

- **ISS Avionics: Command & Data Handling, Comm & Track, Environment & Life Support, Power, Robotics, Thermal Control**
 - **Safety-Critical - hardware that must remain powered and operational - low Single Event Latch-up (SEL) susceptibility**
 - **> 400 equipment items susceptible to SEL that can (& should be) powered down in the event of a large solar flare**
- **Russian, European, Japanese - no data available!**



*Mars /01 /03 Electronics - Our
Space Weather Program*

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- **Mars In-Situ Propellant Production (MIPS)**
 - powered off during transit to Mars
 - powered up after landing on Mars surface
 - 16 g /cm**2 of atmosphere
- **Mars Radiation Environment Experiment (MARIE)**
 - must operate in orbit and on surface
 - highly exposed to solar flare particles
- **components certified by proton testing and flight experience**



*GFE Electronics - Our Space
Weather Program*

EA44/Station Engineering Office

Pat O'Neill

02/09/00

- **GFE Avionics for Shuttle and Space Station:
Data Processing, Comm & Track, Video systems, ...**
 - mostly qualified for space flight by testing with 200 MeV protons
 - 10 yr lifetime reasonably assured for nominal space weather
 - large solar flare with a hard heavy ion spectrum could induce failures not observed in tests



*Space Weather measurement
products & requirements*

EA44/Station Engineering Office

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- **Highest priority:
differential energy particle
spectra as a function of time
inside / outside
magnetosphere**
- **ion species ($z=1$ to 28)
(spectra for selected elements
would be acceptable
- helium, protons, oxygen ,
iron)**
- **energy (10 to 2000 MeV/n)**



*Space Weather measurement
products & requirements*

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- **Priority 2:**
 - **Geomagnetic weather index (Kp)**
 - **function of time**

- **Priority 3:**
 - **Early Warning**
 - **Space Station needs time to prepare shut down equipment**